**Lesson Title: Productive Struggle**

**Objectives:**

By the end of this lesson, the student will be able to:

1. Demonstrate intellectual engagement
2. Persevere when faced with time-consuming or complex tasks

**Purpose:**

Research indicates that students need to wrestle with difficult problems to become better problem-solvers. By providing students with these opportunities, they will learn to achieve at a higher level. As instructors, we need to find the fine line between how much we allow them to struggle and when to provide support. When their struggles are productive they will learn to be persistent in problem-solving.

**Brief Description of Activity:**

Students will be provided with a complex task and use the productive struggle protocol to monitor their progress.

**Materials Needed:**

1. Handout 1 - Initial posing of situation
2. Handout 2 – Productive Struggle Protocol
3. Handout 3 – Linear graph of one of the lines from Handout 1 with coordinates
4. Handout 4 – Productive Struggle Reflection Sheet

*Possible classroom supplies:* poster paper with graphs, poster paper to report findings, markers, and dot stickers

**Sequencing Recommendations:**

**Research/Resources:**

**LESSON:**

1)

2)

**INTRODUCTION, LESSON, AND APPLICATION:**

|  |  |
| --- | --- |
| Student | Teacher |
| **1 - Introduction** |  |
|  | Prompt – “keep your work – we are going to take some time diving in and look at some graphs – write everything down” |
| **1A.**  Students may ask question about getting the “right answer” | **Pass out Handout 1**. Let the students know that they will be considering an open ended question. Share that today in class you will be exploring individually and in groups.  **Introduce the hook:**  This problem we are looking at, a lot of you will have had some personal experience. They might care about gas prices and cars.  ***Note:*** There is no scaffolding. This is intentional. |
| **1B.** First Impressions  The students will work independently and quietly.  Students sometimes ask for information | ***Teacher Prompt:*** “What can you determine from the graph?”  Let students make a list – teacher only encourages students to write down ANYTHING.  DO NOT TEACH- YOU STEP ASIDE HERE to encourage students to write down their personal observations of the graph  “There are lots of possible answers, write down what you notice.” |
| **1C**. Share list with a partner  Students might push back | Teacher uses a pairing technique to pair students. This is a task for two students. If there is an odd number of students have one group of three.  **Handout 2**  *Teacher Prompt* “We have listed some questions for you to think about together. Use these to guide your discussion.”  “This is part of a process; write down what you notice now.”  Put up 4 blank posters with the questions on them. Have markers and stickers ready. |
| **1D.** Class Share out  Now reflect – Add any new thoughts to Handout 1 | Asks pairs to get up and add their observations to the posters  If a pair agrees with a previous statement the pair can add a sticker next the statement.  Teacher sums up each poster.  ***Teacher Prompt:*** “Anything anyone wants to add or delete”  ***Teacher Prompt*:** “Have your determinations changed after listening to your peers?” |
| **One Line Focus** |  |
| **2A.** | **Handout 3** (only one line from the initial graph)  ***Teacher Prompt*:** “Look at the graph now – the values for an ordered pair has been added.” |
| **2B.** Students work alone | ***Teacher Prompt*:** “What can you determine from the graph now? “  ***Teacher Prompt*:** “Work quietly and give everyone an opportunity to think.”  Let students work |
| **2C.** Share with your partner. |  |
| **Assigning Values** |  |
| **3A.** With partner | Hand out another copy **Problem 1 Handout**  ***Teacher Prompt:*** “Look at the original graphs – consult with your partner. Assign values to ordered pairs for each of the lines that make sense to you and are consistent with the known points.” |
| **3B.** | ***Teacher Prompt:*** “Now what can you calculate and determine from the graph?” |
| **3C.** | ***Teacher Prompt:*** “Now that you have these numbers? How would you write a quiz question related to what you have calculated? Be sure to include the answer.” |
| **Summarization of Concepts** |  |
| **4A.** Compare with partner | ***Teacher Prompt*:** “What did you notice?” |
| **4B.** Report out in class | As students report offer definitions of vocabulary as useful and necessary to aid communication (see below) |
| **Reflection** |  |
| **5A.** | ***Teacher Prompt:*** “We are going to take some time to look at the process as you worked through this problem. You will need your notes and scratch paper to help you reflect on your process”  Present questions as per PowerPoint |
| **5B.** Students get Learning Progression Matrix to trace their path and write out their path of learning. | **Learning Progression Matrix Handout**  ***Teacher Prompt:*** “Here is a model – to chart your learning path. What was your path to understanding these ideas?”  ***Teacher Prompt:*** “What helped you move from one box to the next? |
| **5C.** Report out |  |
| **5D**. Reflection - Minute Paper | ***Teacher Prompt:*** “What did you master and how do you know it?” |

**ASSESSMENT:**

1. Quiz question with answer (3C)
2. Learning Progression Matrix (5B)
3. Minute Paper (5D)

|  |  |
| --- | --- |
| **VOCABULARY**  **(dependent upon course)** | **PRACTICE SKILLS**  **(for possible inversion)** |
| Graph | Identify and calculate *x* & *y* intercepts |
| Intercepts | Label axes |
| Ordered Pairs | Calculate slope of a line |
| Axes | Interpret the slope |
| Slope | Match and compare slopes with graphs |
| Rate of change | Draw a graph from a story |
| Domain/Range | Create a situation from a graph |
| Input/output | Write an linear equation given specific points with or without slope |
| Right Triangles | Determine whether a point is a solution to a linear equation |
| Piecewise | Determine domain and range |
| Function | Use function notation (beginning stages) |
| Mastery | Write piecewise functions using set notation |
| Dependent &  Independent Variable | Interpret points of intersection |
|  | Interpret scale |

**EXTENSIONS:**

* What would happen to the graphs if the axes switched? What would the slope represent if that happened?
* What if the horizontal axis tracked miles traveled instead of time traveled? What would those lines look like? What would the slope represent?
* What if Vehicle A was towing a vehicle. How would the graph change if the Vehicle A was not towing a vehicle?
* Is there a way to write an equation that would tell you the number of gallons of gas in the tank of Vehicle A after t hours?
* In this problem, all the cars are traveling at 60 miles per hour the whole time. Is this reasonable? What do you think the graphs would look like in the real world?
* How can equivalent information be represented by different graphs
* Create a situation to match a graph (not necessarily linear)
* Follow up with more rate ideas such as:
  + Mileage and gas volume
  + Rainfall and accumulated rain
  + Interest rate and interest
  + Unit price and total spent
  + Water leak and water level
  + Hill slope and elevation
  + Velocity and Position
  + Weight loss and weight
  + Savings rate and bank balance
  + Wage and paycheck
  + Bags of M&M’s and number of green M&M’s